SPECIFICATION

TITLE

CARTRIDGE FOR DIALYSIS CONTAINING SODIUM BICARBONATE

BACKGROUND OF THE INVENTION

This invention relates to dialysis cartridges containing solid sodium bicarbonate.

It has long been known to use cartridges containing drugs, or other substances, in solid form and to pass water or a solution through the cartridge to dissolve the solid substance continuously, e.g., for continuous administration to a patient. Examples of such cartridges are WO-A-86/03417 and US-A-4432756.

It is also known, as disclosed in EP-A-0278100 to provide sodium bicarbonate in solid form for use as a buffer in hemodialysis. Sodium bicarbonate is stored separately from the rest of a dialysis solution, which contains calcium and magnesium ions, to prevent calcium and magnesium carbonate precipitation. A cartridge of sodium bicarbonate powder is inserted in a hemodialysis machine and water is passed through the cartridge. The powder is gradually dissolved, so that a solution of sodium bicarbonate is continuously produced. The solution is continuously flowed through the machine, mixing with the rest of the dialysis solution in-line upstream of the dialyzer. There is, therefore, only a short dwell time in the machine after mixing, so that the problem of calcium and magnesium carbonates being precipitated is avoided.

A problem does, however, arise with such cartridges. The pH of the mixed dialysis solution is monitored upstream of the dialyzer. If the pH falls outside a given range, then an alarm is triggered. It has been found that this often happens during the first twenty minutes of flow, when the machine is being set up for operation. After this period, no problems are encountered. This causes substantial inconvenience to personnel operating hemodialysis machines, since the problem has to be investigated and the machine reset, each time the alarm is triggered.

The inventors have discovered that the problem is probably caused by contamination of the sodium bicarbonate powder with a small amount of sodium carbonate. The bicarbonate is less soluble than the carbonate, so that a high pH is caused by the dissolution of the carbonate in the early stages. Once the carbonate has

dissolved, the problem disappears. It is, however, difficult and expensive to produce a sodium bicarbonate powder, which is not contaminated with sodium carbonate.

A possible solution to the problem once it was realized that sodium carbonate precipitation was the cause, would be to introduce a further line upstream of the pH monitoring device to add dilute acid solution to the dialysis solution during the first twenty minutes of use of the cartridge. This could be done upstream or downstream of the cartridge. This involves, however, modification of the dialysis solution, use of an additional solution and additional operational control.

The inventors have found that the problem can be relatively simply solved by modifying the contents of the cartridge.

SUMMARY OF THE INVENTION

The present invention relates to a cartridge having an openable sealed inlet and an openable sealed outlet, for connection in-line in a hemodialysis machine for passage of water, or a solution through the cartridge, the cartridge containing sodium bicarbonate in solid form.

In accordance with the invention, the cartridge additionally contains a component chosen from the group consisting of an acid, or acid anhydride in solid form, or carbon dioxide gas.

When the cartridge is mounted in a hemodialysis machine and water is passed through the cartridge, the acid or acid anhydride (including carbon dioxide) is gradually dissolved, decreasing the pH of the resulting solution to counteract any temporary increase in pH caused by sodium carbonate contamination.

The amount of acid or acid anhydride provided is preferably predetermined, so that it is leached from the cartridge during the initial 10 to 30 minutes, i.e., during the period that sodium carbonate is also likely to be leached from the cartridge.

Carbon dioxide may be added to the cartridge, during manufacture, in solid form, i.e., as dry ice, prior to sealing the cartridge.

Acids which may be used in solid form may be organic acids, e.g., citric acid, or tartaric acid, citric acid being preferred for clinical acceptability.

The cartridge may contain at least 0.2g of acid, or acid anhydride per 1000g of sodium bicarbonate; preferably at least 0.5g per 1000g and most preferably at least 1g per 1000g. In a preferred embodiment the cartridge contains 2.7g per 1000g.

Additional features and advantages of the present invention will be described in and apparent from the detailed description of the presently preferred embodiments and the figures.

DRAWINGS

The invention is described with reference to the accompanying drawings, wherein:

Fig 1. is a side elevation of a cartridge according to the invention, shown partly in cross-section; and

Fig 2. is a diagrammatic illustration of the cartridge of Fig 1 connected in a hemodialysis machine.

DETAILED DESCRIPTION OF THE INVENTION

The construction of hemodialysis machines is well known, as is the construction of a sodium bicarbonate cartridge for use in a hemodialysis machine. The machine and the cartridge are not, therefore, described in detail. The cartridge may be of the type sold under the trademark EASYCART by Bieffe Medital S.p.A. of Italy.

Referring to the figures, the cartridge 10 comprises a body 14, closed by a lid 15 and defining a chamber 11. The body and lid are preferably injection molded in polypropylene. The chamber 11 contains sodium bicarbonate in granular, crystalline form, although other solid forms are possible. The lid 15 is sealed to the body 14 by ultrasonic welding. The lid 15 has an inlet 12 and the body had an outlet 13, both sealed closed in the as-molded state, by integral membranes 17, 18 respectively.

The cartridge 10 is connected in-line in a first line 20 for receiving deionized water at 21 and supplying sodium bicarbonate solution to a main line 22, at 23. The membranes 17, 18 are perforated during clamping of the cartridge into the machine, by piercing means provided on the machine. The main line 22 also receives deionized water at 24. A container 30, containing a solution of the other ingredients of a dialysis solution, is connected to the main line 22 by a second line 25 at 26. A final dialysis solution is formed at point 26 and the main line 22 feeds this to a dialyzer 40. A pH detector 50 is connected to the main line 22 downstream of point 26 and upstream of the dialyzer. The detector is connected with a control system (not shown), which produces an alarm, if a pH outside a predetermined range is exceeded. This

range is usually 6.8 to 7.9 pH may be monitored by other means, such as by conductivity measurement.

The solution in the container 30 may contain any of the components usually provided in a dialysis solution, such as calcium and magnesium chloride, sodium chloride and an osmotic agent, such as dextrose.

In accordance with the present invention, the cartridge contains, in addition to the sodium bicarbonate, an acid or acid anhydride in solid form, or carbon dioxide gas, so as to avoid any sodium carbonate contamination causing a temporary increase in the pH of the dialysis solution to a degree sufficient to exceed the predetermined threshold and trigger an alarm.

A preferred embodiment of a cartridge contains 750g sodium bicarbonate and 2g citric acid, both in granular, crystalline form. A similar weight ratio could be used with different amounts of sodium bicarbonate.

Alternatives to citric acid are preferably provided in the same weight ratio.

By way of example, and not limitation, tests were carried out using cartridges containing 750g sodium bicarbonate and citric acid, tartaric acid, or carbon dioxide (added as dry ice) respectively. These were compared with similar cartridges, to which no acid or carbon dioxide had been added.

The tests were carved out by running an Integra (trademark), hemodialysis machine, using the various cartridges. Notes were made of which cartridges produced an alarm signal, due to the pH of the mixed dialysis solution falling outside the predetermined range. The actual maximum pH of each solution was also recorded. "Acid" solutions, i.e., the solutions carrying the other components of the dialysis solution, were standard solutions produced by Gambro. In each case, the pH of the water supplied was 6.1. The results are shown in the tables below. There were numerous false alarms with the reference cartridges, but no false alarms with the cartridges according to the invention.

Table 1

This shows the results using the reference cartridges, containing 750g sodium bicarbonate and no added acid or carbon dioxide.

Sample No.	Maximum pH of dialysis solution	Alarm Yes/No
1	7.9	No
2	7.8	No
3	8	Yes
4	8.1	Yes
5	7.9	No
6	8	Yes
7	8.2	Yes
8	8	Yes
9	7.4	No
10	7.4	No

Table 2

This shows the results using cartridges according to the invention, containing 2g citric acid and 750g sodium bicarbonate.

Sample No.	Maximum pH of dialysis solution	Alarm Yes/No
11	7.5	No
12	7.5	No
13	7.5	No
14	7.5	No
15	7.4	No
16	7.4	No
17	7.4	No
18	7.4	No
19	7.4	No
20	7.4	No
21	7.4	No

Table 3

This shows the results using cartridges according to the invention, containing 0.5g or lg of carbon dioxide (dry ice) and 750g sodium bicarbonate.

Sample No.	Amount of C02(g)	Maximum pH of dialysis solution	Alarm Yes/No
22	0.	7.5	No
23	1.	7.3	No
24	0.	7.5	No
25	1.	7.3	No
26	1.	7.3	No

Table 4

This shows the results using cartridges according to the invention, containing 1g tartaric acid and 750g sodium bicarbonate.

Sample No.	Maximum pH of dialysis solution	Alarm Yes/No
27	7.5	No
28	7.5	No

Other tests were carried out using different "acid" solutions, and water of different pH. In each case, a cartridge according to the invention did not cause any alarm due to either high or low pH.

It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present invention and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claims.